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DESCRIPTION

METHOD AND APPARATUS FOR PRODUCING MOLD

Technical Field

This invention relates to a method and an apparatus for producing a mold by machining a mold material produced by casting, and it can be used for production of a mold for pressing work, a mold for injection molding, and the other molds.

Background Art

On production of a mold for pressing, for example, with a casting as a material, machining such as cutting work and the like for long hours is conventionally required to finish a cast material for a mold to be a mold.

Specifically, after a mold material being a material for a mold is cast, the mold material is machined and finished to be a mold, and on casting of the mold material, a large allowance is given to a margin for work for machining because not only a cast mold model being a basis of the mold material is manually produced in many cases, but also the precision of casting itself is low. Specifically, if the amounts of precision of a model and casting deformation are estimated, the margin for work becomes large from the viewpoint of the safety and the casting shrinks to a large extent or the like on casting, thus making it necessary to prevent the cutting margin from running short.

As a result, as a waste portion of the cast mold model being a basis of the mold material increases, the margin for work of the mold material tends to

be larger than necessary.

On the other hand, the mold industry is required to satisfy the demands for complication of the shapes of the products formed from molds, reduction in the cost and lead time of molds due to the recent social situation.

Accordingly, reduction in the margin for work can be considered to reduce the machining time for a mold material, but even if a numerically controlled working machine or the like is used for the production instead of manually making a cast mold model, a mold with high precision cannot be expected when a casting is used as the mold material, and as a result, the margin for work cannot be sufficiently reduced, which makes it impossible to reduce the machining time.

In view of the above-described fact, an object of the present invention is to provide a method and an apparatus for producing a mold capable of reducing a machining time after the casting of a mold material.

Disclosure of the Invention

A method for producing a mold according to the present invention is characterized by comprising a step of producing a mold material by casting, a step of obtaining measurement data by measuring a shape of the mold material by a measuring device, and a step of working a reference plane and a product forming plane of the mold material by a mold working machine to reduce a work amount of the product forming plane of the mold material based on this measurement data to thereby produce a mold.

Thus, in the method for producing the mold, after the mold material is produced by casting, the shape of this mold material is measured at first. Next, the reference plane and the product forming plane of the mold material

is worked by the mold working machine so as to reduce the work amount of the product forming plane of the mold material based on the measurement data obtained above to thereby produce the mold.

Since the product forming plane of the mold is a plane for forming a worked material such as a metal plate or the like in a predetermined shape, it is formed into a complicated shape, and thus the product forming plane of the mold material is also formed into a complicated shape. In the present invention, the reference plane and the product forming plane of the mold material are worked by the mold working machine so as to reduce the work amount of the product forming plane of the mold material to produce the mold, and therefore the working time can be reduced and the work operation can be efficiently performed when the mold is produced by the machining work from the mold material, thus making it possible to correspond to reduction in cost and lead time of the mold.

If the working amount of the product forming plane of the mold material is reduced, the margin for work of the reference plane of the mold material is sometimes increased on the other hand, but the reference plane that is generally formed into a planar shape can be machined by a large cutter of the mold working machine, and working time and working cost never increase as a whole.

When the reference plane and the product forming plane of the mold material are worked by the mold working machine, the reference plane is previously worked, and the product forming plane is worked with the worked reference plane being as a supporting surface of the mold material in the mold working machine.

According to the above, when the product forming plane is worked,

the worked reference plane is made the supporting surface in the mold working machine, and therefore work can be performed with the reference plane being supported and fixed on the a table of the mold working machine, thus making it possible to machine the product forming plane with stabilized work and high precision.

Further, when the product forming plane is worked by the mold working machine, the product forming plane is worked after the decision as to what portions of the product forming plane are machined and how many times they are machined is made.

According to the above, it becomes possible to finish the production, for example, by machining only the portions with larger working margins of the product forming plane twice and by machining the portions with smaller working margins only once. Specifically, it becomes unnecessary to perform machining many times while detecting what portions are protruded by moving the cutter of the mold working machine over the entire product forming plane, and air cutting time in which only the cutter is moving without working the mold material can be reduced.

The method for producing the mold as described above can be carried out by setting the step of measuring the shape of the mold material with the measuring device and the step of working the reference plane and the product forming plane of the mold material with the mold working machine based on the data obtained by this measurement as the operation steps independent from each other, but it can be also carried out by setting them as the dependent operation steps using a computer.

When they are set as the dependent operation steps using a computer, the measurement data obtained by the measuring device is sent to the

computer, and after the computer performs a computation to reduce a work amount when working the product forming plane of the mold material with the mold working machine based on this measurement data and mold design data stored in the computer, the computer controls the mold working machine to work the mold material.

In order to perform a computation to reduce a work amount when working the product forming plane of the mold material with the mold working machine, on display means of the computer, an envelope model of the mold material generated based on the measurement data from the measuring device and a mold model generated based on the mold design data are displayed, then the envelope model is moved in directions of three axes orthogonal to one another respectively and rotated around the three axes in this display means, thereby bringing this envelope model into close proximity of the mold model, and at this time of its being in close proximity thereof, the computer performs the computation to reduce the work amount of the product forming plane.

Here, bringing the envelope model into close proximity of the mold model means placing all the parts of the mold model inside the envelope model, and bringing a product forming plane of the envelope into close proximity of the product forming plane of the mold model. Thus, from the positional relationship between the mold model and the envelope model, the computation to reduce the work amount of the product forming plane can be performed by the computer with assurance and high precision.

Further, in the case in which a cast mold model used to produce the mold material is produced with a cast mold model working machine, and this cast mold model working machine receives the data from the aforementioned

computer to produce the cast mold model, an estimated amount of deformation occurring when the mold material is produced by casting may stored in the computer, and this data including the estimated amount may be sent to the cast mold model working machine.

According to the above, the cast mold model is formed by the cast mold model working machine into a shape and dimension including the estimated amount of deformation occurring when the mold material is produced by casting, and the mold material formed from the cast mold model can be formed accurately even if casting deformation occurs.

As in the above, when the estimated amount of the casting deformation is stored in the computer, it is preferable to reset the estimated amount with the measurement data about the mold material measured with the measuring device.

When the estimated amount is reset as above, the estimated amount can be rewritten to be more accurate data based on the shape and the dimension of the mold material actually produced by casting, and the next production of the mold material can be carried out more accurately.

When the method for producing the mold described above is carried out by using the computer, one computer may be used, or a plurality of computers performing data communications may be used.

An apparatus for producing a mold according to the present invention is an apparatus for carrying out the method for producing the mold explained above with use of a computer.

Explaining in concrete, an apparatus for producing a mold according to the present invention comprises a measuring device for measuring a shape of a mold material produced by casting, a computer into which measurement

data from this measuring device is inputted, and a mold working machine controlled by the computer to work the mold material and produce a mold from the mold material, and

the computer has storage means for storing the aforementioned measurement data and mold design data, and computing means for computing data for making the mold working machine work a reference plane and a product forming plane of the mold material to reduce a work amount of the product forming plane of the mold material based on these measurement data and model design data.

The computing means previously makes the mold working machine work the reference plane, and thereafter computes data for making the mold working machine work the product forming plane with the worked reference plane being as a supporting surface of the mold material in the mold working machine.

Further, working capability data of the mold working machine is stored in the storage means, and after the computing means computes what portions of the product forming plane are worked and how many times they are worked based on the working capability data, the computing means makes the mold working machine work the aforementioned product forming plane.

Furthermore, the computer has display means for displaying an envelope model of the mold material generated based on the measurement data obtained by the measuring device and a mold model generated based on the mold design data, and operation means for bringing the envelope model into close proximity of the mold model by moving the envelope model in directions of three axes orthogonal to one another respectively and rotating it around the three axes, and by its being in close proximity thereof, the

computation to reduce the work amount of the product forming plane is performed in the aforementioned computing means.

Bringing the envelope model into close proximity of the mold model mentioned here means placing all parts of the mold model inside the envelope model as well as bringing a product forming plane of the envelope into close proximity of the product forming plane of the mold model.

When the apparatus for producing the mold according to the present invention further comprises a cast mold model working machine for producing a cast mold model used for producing the mold material, an estimated amount of deformation at the time of casting of the mold material is stored in the aforementioned storage means, data including this estimated amount is sent to the cast mold model working machine, and the cast mold model is produced by the cast mold model working machine based on this data.

It is preferable to make the aforementioned estimated amount stored in the storage means resettable based on the measurement data about the shape of the mold material measured with the measuring device. When the estimated amount stored in the storage means is the measurement data by the measuring device and resettable, the next production of the mold material can be performed more accurately as described above.

In the above, the storage means of the computer may be any storage by a magnetic disc, floppy-disk, hard disk, optical disk (CD-ROM, CD-R, CD-RW, DVD, etc.), magneto-optic disk (MO, etc.), semiconductor memory, magnetic tape or the like, and may be the combination of two or more of them.

Further, the operation means may be any operation device by a

keyboard, mouse, track ball, joystick, or the like, and may be the combination of two or more of them.

Furthermore, the display means may be a display device such as a display with a visual screen, printer, or the like, but since it is desired to visually show the envelope model being brought into close proximity of the mold model as described above, the display with a screen is preferable.

The computer in the above apparatus for producing the mold may be one, or may be a plurality of computers performing data communications.

An example of a mold to which the method and apparatus for producing the mold according to the present invention is applied is a press mold for pressing work, but other than this, it is also applicable to the production of the molds for injection molding, extrusion molding, pultrusion, blow molding and the like.

Further, when the accurate height dimension of the mold is required, the work amount of the reference plane is set according to the height dimension, but if it is sufficient to form the reference plane of the mold material to be simply a parallel plane with the reference plane of the mold model, the reference plane may be worked to be parallel therewith. In this case, the work amount of the reference plane can be reduced.

Further, the measuring device for measuring the shape of the mold material may be a device of a non-contact image-pickup type using moire, non-contact laser type or stereo type, or further a device for measuring in contact with the mold material.

Furthermore, machining of the mold material may be cutting work, grinding work or the like, or the combination of them. Further, as the cutter for working the mold material, an end mill and the like can be considered, and

as a mold working machine, adopting a machining center and the like are considered. If the mold working machine is a numerically controlled machine tool, machining work of the mold material can be accurately and efficiently performed by utilizing the data from the computer.

Brief Description of the Drawings

FIG. 1 is a block diagram of a mold production support system applied to a method for producing a mold according to one embodiment of the present invention;

FIG. 2 is a sectional view showing a construction of a press mold apparatus;

FIG. 3 is a perspective view showing a mold material for an upper mold of the press mold apparatus;

FIG. 4 is a view showing positional relationship between an envelope model and a mold model; and

FIG. 5 is a view showing positional relationship between a scanning measured model and the mold model.

Best Mode for Carrying out the Invention

Preferred embodiments will be described with reference to the attached drawings in order to explain the present invention further in detail.

A configuration and procedural steps of a mold production support system for carrying out a method for producing a mold according to an embodiment of the present invention will be explained based on the drawings.

As shown in FIG. 1, a computer 12, which is loaded with computer aided design and manufacturing (CAD / CAM) software to constitute a core

part of a mold production support system 10, is connected to a cast mold model working machine 14 being a numerically controlled (NC) machine tool for producing a cast mold model 15, and the cast mold model 15 is worked by this working machine 14 based on mold design data sent from the computer 12. The cast mold model 15 is formed in a shape corresponding to a mold material 20 for a press mold produced by casting, and since data including an estimated amount of estimated deformation by casting, which is stored in the computer 12, is sent to the cast mold model working machine 14, the mold material 20 produced by casing with use of the cast mold model 15 is formed to have a shape and dimension with a margin for work being left for allowing a cutting work being post working performed after the production of the mold material 20. The cast mold 15 may be manually produced.

A measuring device 16 for measuring the shape of the mold material 20 is also connected to the computer 12. As the measuring device 16, a three-dimensional measuring device, which is an image-pickup type utilizing moire, capable of a hexaxial control of the direction of a camera and an image processing type capable of simultaneously processing many points. The computer 12 is loaded with shape measuring support system software having a function of giving an automatic tracking command to the measuring device 16, so that the effective shape measurement can be made.

Here, the measurement data of the mold material 20 measured by the measuring device 16 is made a measured point group, and the measurement data is sent to the computer 12 with an envelope model M2 shown in FIG. 4 being a three-dimensional graphic model virtually formed along the measured point group.

Further, a mold working machine 18 being an NC machine tool for

working the mold material 20 is also connected to the computer 12, so that the mold material 20 can be worked by the mold working machine 18 based on the measurement data measured with the measuring device 16.

The computer 12 has a storage unit 12A, an operation unit 12B, a display unit 12C and a computing unit 12D. In the storage unit 12A, stored are the aforementioned software, mold design data and the data of the estimated amount of the casting deformation, besides which, working capability data of the mold working machine 18, software necessary for computing the work amount by which the mold material 20 is cut based on the mold design data and the measurement data from the measuring device 16 and its computing data, and further stored are software and data necessary for carrying out the mold producing method, which will be explained hereinafter, such as software for driving the cast mold model working machine 14 and software for finishing the mold material 20 to be a mold by the mold working machine 18 based on the measurement data from the measuring device 16. The computing unit 12D performs the execution of the software stored in the storage unit 12A based on a command signal from the operation unit 12B and computing processing based on the data stored in the storage unit 12A. The display unit 12C is a display with a visual screen, which displays the result of computing processing by the computing unit 12D.

According to the above, the mold production support system 10 being an apparatus for producing a mold of this embodiment is constituted by the computer 12, the casting mold model working machine 14, the measuring device 16 and the mold working machine 18, and the casting mold model working machine 14, the measuring device 16 and the mold working machine 18 are driven by being controlled by the computer 12.

The mold material 20 of this embodiment is finished by being subjected to cutting work being a machine work to be a mold, and as a press mold apparatus formed with this mold being included, the structure, in which an upper mold 22 is disposed on an upper portion side shown in FIG. 2 while a lower mold 24 is disposed on a lower portion side, and a lower holder 26 for pressing a metal plate P being a worked material between the lower holder 26 and the upper mold 22 is disposed between the upper and lower mold by being supported by springs 28, is considered as an example. When the upper mold 22 is lowered as the two-dot chain line shows, the metal plate P held by being sandwiched between the upper mold 22 and the lower holder 26 is worked by pressing with the upper mold 22 and the lower mold 24, and thereby formed to be a product.

On producing these molds such as the upper mold 22, the lower mold 24, the lower holder 26 and the like, the production method of this embodiment is used, and for example, the mold material 20 for the lower 24 is cast to be formed as shown in FIG. 3.

Next, the procedure steps of the method for producing a mold according to this embodiment will be explained.

At first, the cast mold model working machine 14 cuts a material of foamed resin based on the mold design data sent from the storage unit 12A of the computer 12 to thereby cut to create the cast mold model 15 corresponding to the mold material 20. Next, by performing casting operation by, for example, the lost-wax process based on the cut cast mold model 15, the mold material 20 to be the material of a mold shown in FIG. 3 is made in a form having a margin for work.

Thereafter, the shape of the mold material 20 is measured by the

measuring device 16, and the measurement data of this measurement result and an envelope model M2 generated based on the measurement data are stored in the storage unit 12A of the computer 12.

Further, after the measurement of the shape of the mold material 20 is finished, not only a reference plane 20A and a product forming plane 20B of the mold material 20, but also a surface 20C of the part of the mold material 20 other than these planes is cut by the mold working machine 18.

On this occasion, the mold design data and measurement data are initially read from the storage unit 12A of the computer 12, and shown on the display unit 12C being the display of the computer 12 so that an operator can see the positional relationship between a mold model M1 being a three-dimensional graphic model based on the mold design data and the envelop model M2 being the three-dimensional graphic model based on the measurement data, as shown in FIG. 4.

In the state shown on the display, the envelope model M2 of the mold material 20 generated based on the measurement data is linearly moved in directions of thee axes X, Y and Z orthogonal to one another and also rotated around the three axes X, Y and X by the operation of the operation unit 12B. It is noted that the envelope model M2 can be linearly moved and rotated automatically by software.

By linearly moving and rotating the envelope model M2, all parts of the mold model M1 is placed inside the envelope model M2, and by bringing the envelope model M2 into close proximity of the mold model M1 as shown in FIG. 5, specifically, by bringing the product forming plane M2B of the envelope model M2 into close proximity of a product forming plane M1B of the mold model M1, the state in which the work amount of the product

forming plane 20B of the mold material 20 becomes minimum and the work amount is reduced is searched for.

When the state in which the work amount of the product forming plane 20B becomes minimum is found out, the position of the envelope model M2 is fixed in this state by the command signal from the operation unit 12B, and the data of the envelope model M2 at this time converted into the coordinate axis of the mold model M1 is obtained, and the three-dimensional graphic model of the obtained data is called a scanning measured model M3.

By obtaining the cutting amount of each portion of the reference plane 20A, the product forming plane 20B and the like of the mold material 20 by the computing unit 12D from the size of a gap between the scanning measured model M3 and the mold model M1, the volume of the cut portions of the mold material 20 is calculated and obtained, and this volume is set as the total cutting amount of the mold material 20.

Further, based on the data of the total cutting amount, the computing unit 12D of the computer 12 not only computes the diameter, rotational frequency, cutting amount, feeding speed and the like of the cutter of the mold working machine 18, but also computes what portions of the product forming plane 20B are cut and how many times they are cut when cutting the product forming plane 20B, based on the working capability data of the mold working machine 18 stored in the storage unit 12A. Specifically, the data that makes it possible to reduce the work amount of the product forming plane 20B is computed by the computing unit 12D from the data stored in the storage unit 12A.

Thereafter, the reference plane 20A, the product forming plane 20B, and the surface 20C of the other parts are respectively cut by the mold

working machine 18, on which occasion, a reference plane working instruction diagram dimensionally indicating the position of the reference plane 20A and the position of the support surface M1A of the mold model M1 from the position of the platen of the virtual mold working machine is initially generated in the computing unit 12D of the computer 12 using the scanning measured model M3, then this reference plane instruction diagram is outputted to the mold working machine 18, and the reference plane 20A being a large plane is cut with the mold working machine 18 at first.

Further, after the cutting work of the reference plane 20A is finished and the surface 20C of the other part is cut, the product forming plane 20B of the mold material 20 is cut with the reference plane being fixedly supported on a table of the mold working machine 18 as the supporting surface.

On this occasion, based on the computation result from the data of the aforementioned total cutting amount, the diameter, rotational frequency, cutting amount, feeding speed and the like of the cutter of the mold working machine 18 are selected, and predetermined portions of the product forming plane 20B is worked by predetermined times, whereby the work of the entire product forming plane 20B is finished while the work amount is reduced.

Next, the operation of the method for producing the mold according to this embodiment will be explained.

In this embodiment, based on the measurement data of the measurement of the shape of the mold material 20, stored in the storage unit 12A of the computer 12, the envelope model M2 of the mold material 20 is generated, and in the display unit 12C, the envelope model M2 is linearly movable in the directions of the three axes X, Y and X orthogonal to one another and rotatable around the three axes. Thus, in such a manner that this

envelope model M2 is brought into close proximity of the mold model M1 generated based on the mold design data, these data can be compared.

As a result of the above, in the display unit 12C, the positional relationship between the mold model M1 based on the mold design data and the mold material 20 can be determined with reliability and high precision, which makes it possible to reduce the work amount of the product forming plane 20B that takes time to be machined.

When the reference plane 20A and the product forming plane 20B of the mold material 20 are cut by the mold working machine 18, the reference plane 20A of the mold material 20 is initially cut, and the product forming plane 20B is cut with the worked reference plane 20A as the supporting surface in the mold working machine 18. Consequently, when the product forming plane 20B is worked, the worked reference plane 20A can be fixed on the table of the mold working machine 18 as the supporting surface, and thereby the mold material 20 is fixed on the table with stability, thus making it possible to work the product forming plane 20B with higher precision and assurance.

Further, when the cutting work is performed for the product forming plane 20B, what portions are cut and how many times they are cut are computed in the computing unit 12D, thus making it possible to finish the production by cutting only the portions having a larger margin for work of the product forming plane 20B, for example, twice, and by cutting the portions having a smaller margin for work only once.

That is, it becomes unnecessary to perform cutting many times while detecting what portions are protruded by moving the cutter such as a cutting tool and the like over the entire product forming plane 20B, and it becomes

possible to reduce the time for air cutting during which the tool is only moving without machining the mold material.

According to the above, when the reference plane 20A and the product forming plane 20B of the mold material 20 are worked on, the margin for work of the product forming plane 20B, which is a plane for forming the pressed material such as a metal plate and the like into a product as a mold for pressing work and is generally regarded to have a complicated surface shape, is reduced and thus the work amount is reduced.

Consequently, even when a casting with low precision is used as a material, the work amount of the product forming plane 20B is reduced and the cutting time can be shortened, thus making it possible to correspond to the complication of the product shape, reduction in the cost and lead time of the molds.

In the case of this embodiment, the margin for work of the reference plane 20A is larger in some cases contrary to the above, but the reference plane 20A which is generally planar can be cut by a large cutter, and the cutting time is not increased to a large extent when the reference plane 20A is worked on.

Next, the cutting time reduction effects by the method and apparatus for producing the mold according to this embodiment will be explained.

Conventionally, when the cutting work being machining is performed for the mold material, the work with multiple stages such as rough machining, semi-finishing machining, finishing machining, and the like is needed. As the condition for cutting the material to be cut having the same shape as the product forming plane by rough machining, the cutter with a diameter of 50 mm is used and when the cutting amount is 10 mm and the rotational

frequency is 800 rpm, the feeding speed is 0.4 m / minute.

On the other hand, as the work amount of the production forming plane is reduced by adopting the production method of this embodiment, the cutting amount is 4 mm, and when the cutter of a diameter of 50 mm is used at the rotational frequency of 1400 rpm, the condition of the feeding speed of 1.05 m / minute is obtained, thereby increasing the cutting speed 2. 6 times as high as conventionally.

Further, the cutting time for the entire mold material under this working condition is estimated to be shorter by about 32% as compared with the prior art, and the working time when the lower holder is produced for trial is reduced by about 10 hours.

Meanwhile, when the rough machining is abolished following the adoption of the production method of this embodiment and machining is performed with a cuter for the semi-finishing machining with the cutting amount of 3 mm at a reduced feed speed, the rotational frequency becomes 1800 rpm while in the conventional semi-finishing machining, the rotational frequency is 2000 rpm with the cutting amount of 0.2 mm, and the condition of the feeding speed of 1.45 m / minute is obtained while the conventional one is 2 m / minute.

Specifically, the cutting speed of the semi-finishing machining becomes lower as a result that the cutting speed is about 0.7 times as high as the conventional one, but it is compensated by the time reduced by abolishing rough machining, and the work time when the lower holder is produced for trial can be reduced by about 13 hours, thus making it possible to improve the efficiency to a large extend.

Next, the analysis of deformation amount in casting the mold material

20 by using the mold production method according to this embodiment will be explained. The deformation occurs in the form of shrinkage and the like when the mold material is produced by casting.

The estimated amount of casting deformation stored in the storage unit 12A of the computer 12 to produce the cast mold model 15 shown in FIG. 1, and the actual dimension of the mold material 20 based on the measurement data obtained by the measurement by the measuring device 16 are compared. According to the above, the operator of the mold production support system 10 can judge whether or not the estimated amount of casting deformation is corrected when the next mold material 20 is produced, and analyze the difference between the estimated amount of the casting deformation and the actual dimension of the mold material 20.

That is, from the difference between the actual casting deformation amount and the estimated casting deformation amount, it is analyzed whether or not the estimated casting deformation amount stored in the storage unit 12A is proper or not, and in the next production of the mold material 20, the estimated amount of the casting deformation can be reset.

The reset estimated amount of the casting deformation is stored in the storage unit 12A, and when the cast mold model 15 for producing the next mold material 20 is produced, the data of the estimated casting deformation amount is sent to the casting mold model working machine 18, whereby the cast mold model 15 in the shape and dimension including the estimated amount is produced.

Industrial Availability

As in the above, the method and apparatus for producing the mold

according to the present invention is suitable for producing a mold used for pressing work and the like.